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11.—*Murchisonia*, a new monotypic genus of Liliaceae from Western Australia

by N. H. Brittan*

Manuscript received 16 March 1971; accepted 22 June 1971

Abstract

A monotypic new genus *Murchisonia fragrans* Brittan (Liliaceae) having affinities with *Thysanotus* R.Br. and *Bottionea* Colla is described and illustrated.

Introduction

Specimens of a liliaceous plant were collected by the author from a locality in the Murchison District, Western Australia, in October 1968 and again in August 1970. On the first occasion all plants were in fruit, although there was one partly open flower; on the second occasion adequate flowering material was obtained.

The specimens, in common with *Thysanotus* R.Br. and *Bottionea* Colla, are distinguished from other liliaceous genera by the presence of fimbriate inner-perianth segments. The fimbriae appear not to be as numerous or as well developed as in *Thysanotus*. Fresh flowering material of *Bottionea*, a Chilean genus, has not been seen by the author, but illustrations show a well developed "fringe" (Colla 1834, Curtis 1831, Lindley 1832).

The flower differs from both *Thysanotus* and *Bottionea* in possessing a markedly urceolate base resulting from the adnation of the bases of the two series of perianth segments (Fig. 1c, d) as reported by Baker (1876) for *Asphodelus* and *Asphodeline*. These latter two genera, however, possess 1-nerved perianth segments and distinctive funnel- or bell-shaped flowers.

The stamens and style of the specimens are actinomorphic to very slightly declinate arranged (Fig. 1b) rather than markedly declinate as in *Thysanotus*. The specimens have basifixed anthers equal in length to the filaments, whereas in *Bottionea* the anthers are approximately one quarter of the length of the filaments. With regard to the mode of attachment of the anthers of *Bottionea* there are conflicting statements. Bentham and Hooker (1883) state that the anthers are dorsifixed. Hutchinson (1959) uses "anthers basifixed or nearly so, not versatile" as a positive lead in the key to the genus, whereas Baker (1876) states that the anthers are versatile. Colla (1834) in the original description makes no reference to this character.

At the time of dehiscence the anthers of both the Murchison specimens and *Thysanotus* are two-loculate as a result of the breakdown of internal septa. In *Thysanotus* the inner pair of the four original loculi are shorter than the

outer pair and this character is visible in the mature anther. This is not the case in the Murchison specimens in which the loculi are all equal in length. The dehiscence is by longitudinal slits only, compared with *Thysanotus* where dehiscence takes place either by a terminal pore alone, or a terminal pore which later develops into slits.

In the articulation of the pedicel, the persistence of the perianth parts around the developing capsule, in the attitude of the leaves (Fig. 1a) (recalling particularly *T. scaber*), in the capsule slightly longer than broad (Fig. 1f) and in the seeds which are shiny black and arillate, the specimens approach *Thysanotus*. They agree with the majority of *Thysanotus* species in possessing six ovules, whereas *Bottionea* is reported as having a large number of ovules and a capsule much longer than broad.

In the author's opinion the specimens cannot be referred either to *Thysanotus* or *Bottionea* or any other liliaceous genus. It is therefore proposed to establish a new genus *Murchisonia*, family Liliaceae, Juss; subfamily Asphodeloideae Vent.; tribe Asphodelae Koch; subtribe Anthericinae Engl. (Krause 1930).

Murchisonia fragrans gen. et sp. nov.

Herba perennis; rhizoma parvum. Tubera cylindrica 3-10 cm longa in radicibus fibrosis 12-18 cm longis. Folia 6-16, inclinata unilateralia, linearia plus minusve teretia, 30-33 cm longa 1-2 mm lata, basin versus canaliculata, basi in vaginas membranaceo-marginatas expansa, ab vaginis membranaceis ad 8 mm latis sine laminis obtectas. Scapus procumbens, 12-14 cm longus, simplex, in spicam laxam umbellis paucis multifloris terminans. Bracteae umbellarum membranaceae, lanceolatae, 3-5 mm longae. Pedicelli 10 mm longi, circa 4-5 mm supra basin articulati. Flores viridi-albi, 16-18 mm dia., odorem subtilem persistentem exhalantes. Tepala 6, biseriata, basi adnata urceolata. Tepala exteriora lanceolata, 5-nervata, 2.5 mm lata, anguste membranaceo-marginata, apicibus mucronatis. Tepala interiora lanceolata, 3-nervata, 3 mm lata, apices versus fimbriata. Stamina 6, similia, erecta; filamenta complanata, 3 mm longa, libera, basi urceoli inserta. Antherae atro-purpureae, 3 mm longae, lanceolatae, basifixae; loculi basi breviter divergentes, rimis introrsim dehiscentes. Ovarium sessile, sub-cylindricum, triloculare, utroque loculo ovulis 2. Stylus terminalis, erectus, strictus. Capsula cylindrica, 5 mm longa, 3 mm lata, ab perianthio persistente inclusa, loculicide dehiscens. Semina nigra, arillata, angulata, ca. 1.5 mm dia.

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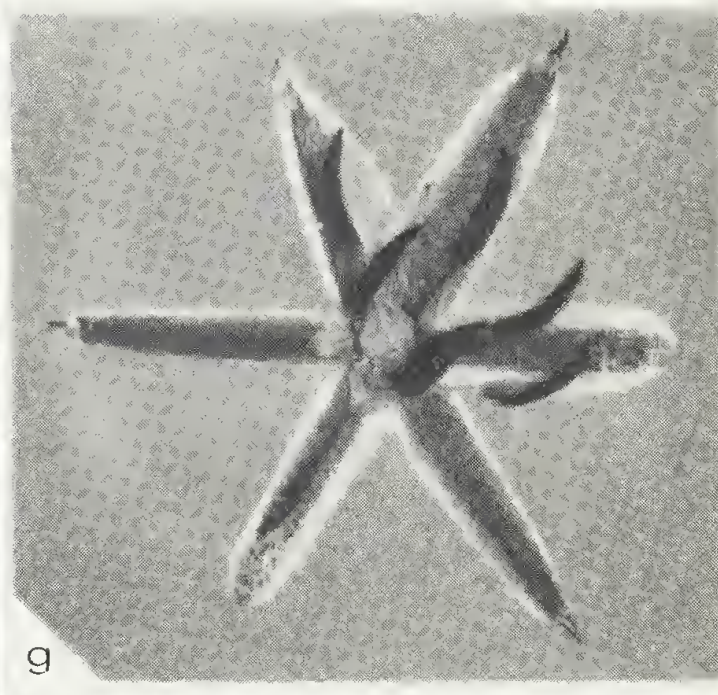
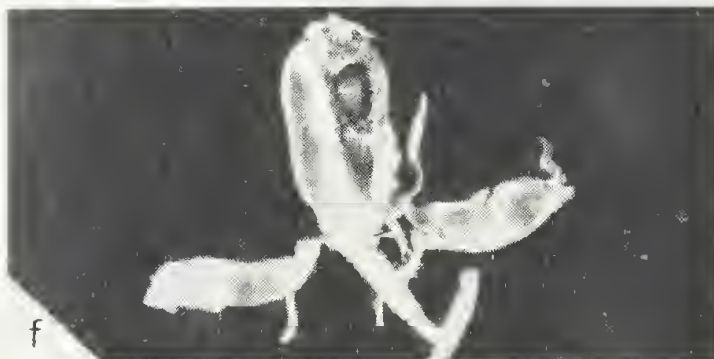
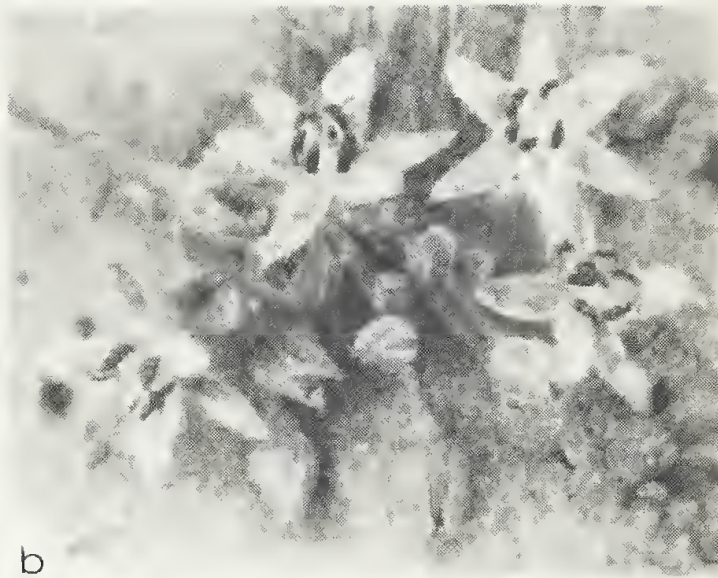
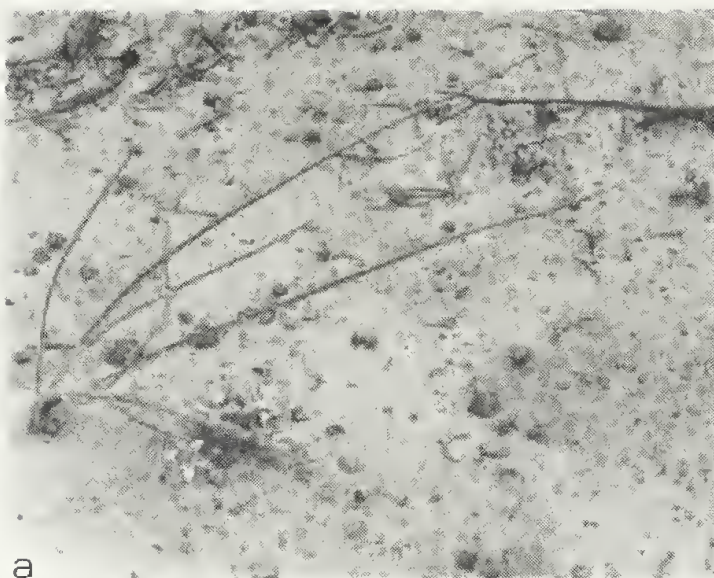


Figure 1.—*Murchisonia fragrans* N. H. Brittan. a. Habitat of Plant. b. Inflorescence (ca. $\times 1.5$). c. Pressed half-flower showing adnation of tepals to form urceolate base. Note membranous edges to outer tepals and mucronate apices ($\times 5$). d. Pressed half-flower showing insertion of anther filaments at base of urceolus. Note fimbriae of inner tepal ($\times 5$). e. Inflorescence axis after flowers have fallen showing sessile umbels with bracts ($\times 3$). f. Half capsule with two seeds in loculus ($\times 3$). g. Pressed flower showing fimbriae of inner tepals inrolled on drying. Note flattened anther filaments ($\times 4$).



Figure 2.—*Murchisonia fragrans* N.H. Brittan. Paratype—near 390 mile peg North-West Coastal Highway (ca. 45 miles north of Northampton, Western Australia), Brittan, 68/22. 22. x. 1968. (x 0.5)

Holotypus: near 390 mile peg. North-West Coastal Highway, in gravelly sand, *Brittan* 70/11, 25 viii, 1970 (UWA).

Paratypus: *ibid.* *Brittan* 68/22, 22 x 1968 (K).

Perennial herb; rhizome small; numerous fibrous roots becoming expanded at 12-18 cm from rhizome into cylindric tubers 3-10 cm long. Leaves 6-16 linear, terete 30-33 cm long, 1-2 mm wide, channeled at the base, expanded below into membranous-margined sheaths surrounded by membranous leaf sheaths 8 mm wide without laminas. Leaves inclined to one side. Scapes 12-14 cm long, unbranched, procumbent, bearing a lax spike of few many-flowered umbels. Umbel bracts membranous, lanceolate, 3-5 mm long. Pedicels 10 mm long, articulated 4-5 mm from base. Flowers greenish white, 16-18 mm dia. with delicate persistent perfume. Tepals 6 in two series, adnate at base forming an urceolus. Outer tepals lanceolate, 5-nerved, 2.5 mm wide, with narrow membranous margins; apex mucronate. Inner tepals lanceolate, 3-nerved, 3 mm wide, with wider membranous margins, loosely fringed towards apex. Stamens 6, similar, erect; filaments flattened, 3 mm long, free, inserted at the base of the urceolus. Anthers dark purple, 3 mm long, lanceolate, basifixed, loculi diverging shortly at

base, dehiscing by slits introrsely. Ovary sessile, subcylindrical, trilocular with 2 ovules in each loculus. Style terminal, erect, straight. Capsule cylindrical, 5 mm long, 3 mm wide, included in the persistent perianth, dehiscing loculicidally. Seeds black, arillate, angular, ca. 1.5 mm dia.

Acknowledgements

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The author is grateful to Mr. A. S. George of the Western Australian Herbarium for his assistance in checking the latin description.

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12.—Observations on the reproductive biology of the dibbler, *Antechinus apicalis* (Marsupialia: Dasyuridae)

by P. Woolley*

Manuscript received 18 May 1971; accepted 27 July 1971

Abstract

The dibbler, *Antechinus apicalis* is a rare species and only 10 animals (3 wild-caught and 7 laboratory reared) were available for study. Comparisons with *A. stuartii* have been made to better interpret the limited data obtained. The dibbler breeds only once a year, in the autumn. Both males and females are sexually quiescent at other times of the year. The gestation period is estimated to be from 44 to 53 days. The young are dependent on the mother for approximately 4 months and they reach sexual maturity in the breeding season of the year following that in which they were born, when they are about 10 to 11 months old. There is some evidence that both males and females may breed in successive breeding seasons.

Introduction

In January 1967 Morcombe (1967) collected the first dibblers which had been seen for 83 years. Two specimens, one male and one female, were trapped. Later, in April 1967, Ride (1970) captured another female. These three dibblers were sent to the author at La Trobe University in May 1967 for study of their reproductive biology.

Reproductive Status of the Wild-caught Dibblers

Male 1 (trapped 28th January, 1967). In other species of *Antechinus* spermatozoa are found in the urine during the breeding season and the onset of spermatorrhea is associated with an increase in the size of the scrotum (Woolley, 1966a). Male 1 was not showing spermatorrhea when received in May. However, it may have been in breeding condition earlier in 1967, when the scrotum was reported to be large (Ride, pers. comm.).

Female 2 (trapped 26th January, 1967). In May the pouch area of this female was small and covered with short, pale hairs. The eight nipples were minute. The appearance of the pouch area was similar to that of other species of *Antechinus* prior to breeding (Woolley, 1966a). Female 2 therefore appeared either to be immature, or to have failed to suckle young in an earlier breeding season.

Female 3 (trapped 8th April, 1967). At the date of capture the pouch of this female contained no young, but the pouch area was covered with long, brown-stained hairs (Ride, pers. comm.). In other species of *Antechinus*, females which have reared young can be recognised by the discoloration of the pouch hairs which occurs during lactation (Woolley, 1966a).

Ride's observation therefore suggested that female 3 had previously suckled young. Female 3 was examined again by Ride on 6th May and an uncounted number of small, hairless young were found in the pouch. These young must have been conceived in the wild before 8th April, since female 3 had been caged alone from the date of capture. When female 3 was received on 11th May, there were eight young in the pouch. By comparison with young of known age of other species of *Antechinus* (assuming similar growth rates) the young of dibbler female 3 were estimated to be two weeks old. Birth of the young therefore probably occurred late in April.

Maintenance of the Dibblers at La Trobe University

The animals were held in an air-conditioned room at approximately 21°C under the natural day length conditions of Melbourne. They were housed in cages that had been used previously for the successful maintenance of other species of *Antechinus*. The cages were made of stainless steel, 42 cm. x 31 cm. x 23 cm. high, with removable glass fronts. Each cage had a single detachable stainless steel nest box 13 cm. x 13 cm. x 13 cm. with access through a 5 cm. square hole on one end of the cage. The back and top of the cage were made of 3 mm. stainless steel mesh, on which the animals could climb. A sheet of corrugated cardboard, covered with wood shavings, bark and leaves, was used as floor covering and small pieces of cardboard and shredded paper were provided for nest material. The animals sometimes carried floor covering material into their nest boxes. Initially male 1 and female 2 were caged together and female 3, with pouch young, was caged alone.

The basic diet consisted of a mixture of raw minced meats, egg and fine ground dried puppy food, in the proportion of 450 g. sheep heart, 115 g. sheep liver, 1 sheep brain, 1 egg and 100 g. puppy food. The animals were fed once a day, in the late afternoon. Each animal was given 15 g. mince daily. Larger quantities were eaten by female 3 during the later stages of lactation. The basic diet was supplemented with insects and *Eucalyptus* and *Banksia* blossoms when available. Water, and honey diluted 1 to 5 with water, were provided *ad lib*.

History of the Dibblers in Captivity

Male 1 and female 2 (May–August 1967). From May to August, male 1 and female 2 were examined at irregular intervals of from 2 to 4 weeks.

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Female 3 and litter (May-August 1967). No attempt was made to study in detail the development of the pouch young. Under laboratory conditions the mortality of young during pouch life was found to be very high in *A. stuartii* and many young died when between 35 and 45 days old (Woolley, 1966b). Since this mortality may have been due to the regular handling to which the *stuartii* were subjected, the *apicalis* female with young was not handled at all until 22nd June, when the young were approximately eight weeks old. One young had been lost. The remaining seven were haired all over and their eyes were still closed. Up to 22nd June, female 3 was rarely observed out of the nest box during daylight hours, but in late June and early July she was frequently observed out in the cage with the young hanging from the nipples. She was first seen out without her young on 13th July and on the following day one juvenile was found out in the cage alone. The eyes were open and it was able to climb on the wire of the cage. During the last two weeks of July, the young were often seen out in the cage without the mother. On 30th July, when the young were approximately 13 weeks old, the female and young were examined. There were 3 male and 4 female young. The pouch area of female 3 was large and the pouch hairs a deep reddish-

Wild-caught and laboratory reared animals (from September 1967). Early in September the dibblers were marked with their serial number by a system of toe clipping (Woolley, 1966b). The laboratory reared females were numbered 4, 5, 6 and 7, and the males 8, 9 and 10. Each male was caged with either one or two females. The combinations of males and females were changed as individuals died, and also during the period when it was expected that mating might occur. The animals were usually examined at intervals of two weeks throughout the remainder of 1967 and at weekly intervals while they were maintained in the laboratory in 1968. Males were weighed, the width of the scrotum measured and urine collected for examination for spermatozoa. Females were weighed and the pouch area inspected.

Figure 1 shows the body weight, width of the scrotum and the occurrence of spermatozoa in the urine for each male from September 1967 to the date of death (males 1, 8 and 9) or to the end of May 1968 (male 10). The males were killed at various times in 1968 when they became unhealthy. Histological sections were prepared of one testis and epididymis of each male. The occurrence of spermatogenesis and of spermatozoa in the testis, epididymis and urine at death is given in Table 1.

TABLE 1

The occurrence of spermatogenesis and spermatozoa in the four males at the date of death.

Male No.	Date of Death	Spermatogenesis	Spermatozoa		
			In Testis	In Epididymis	In Urine
1	24/1/68	Yes	No	No	No
8	26/4/68	No	Yes	Yes	Yes
9	11/3/68	No	Yes	Yes	No
10	25/9/68	No	No	No	No

Two males (8 and 10) showed spermatorrhea in January and spermatozoa continued to appear in the urine for approximately 4 months. As in *A. stuartii* (Woolley, 1966a) the body weight and width of the scrotum increased with the approach of the breeding season. In the

dibbler scrotal width reached its highest level before the onset of spermatorrhea, and body weight was maximal during the period when the males were showing spermatorrhea. Male 8 was killed late in April, and, although spermatozoa were still present in the testis, epididymis and urine, spermatogenesis had ceased. Male 10 ceased to show spermatorrhea at the end of April. Males 1 and 9 did not show spermatorrhea. However, the occurrence of spermatogenic cell divisions in the testis of male 1 in January suggests that this male was coming into breeding condition at the time of death. In male 9, spermatogenesis had occurred, because there were spermatozoa in the testis and epididymis, but had ceased in March. There is no obvious explanation for the failure of male 9 to show spermatorrhea.

Observations on Reproduction in the Female

Mating occurred in March and April. The onset of oestrus was detected by observation of attempts by the males to court the females. The pattern of courtship and copulation was similar to that described for *A. stuartii* by Marlow (1961). Of the four females which were observed to mate, one copulated once, two twice, and one four times. When the females persistently resisted further attempts by the male to copulate the pairs were separated and the females caged alone. The maximum duration of a single copulation was 5 hours and the

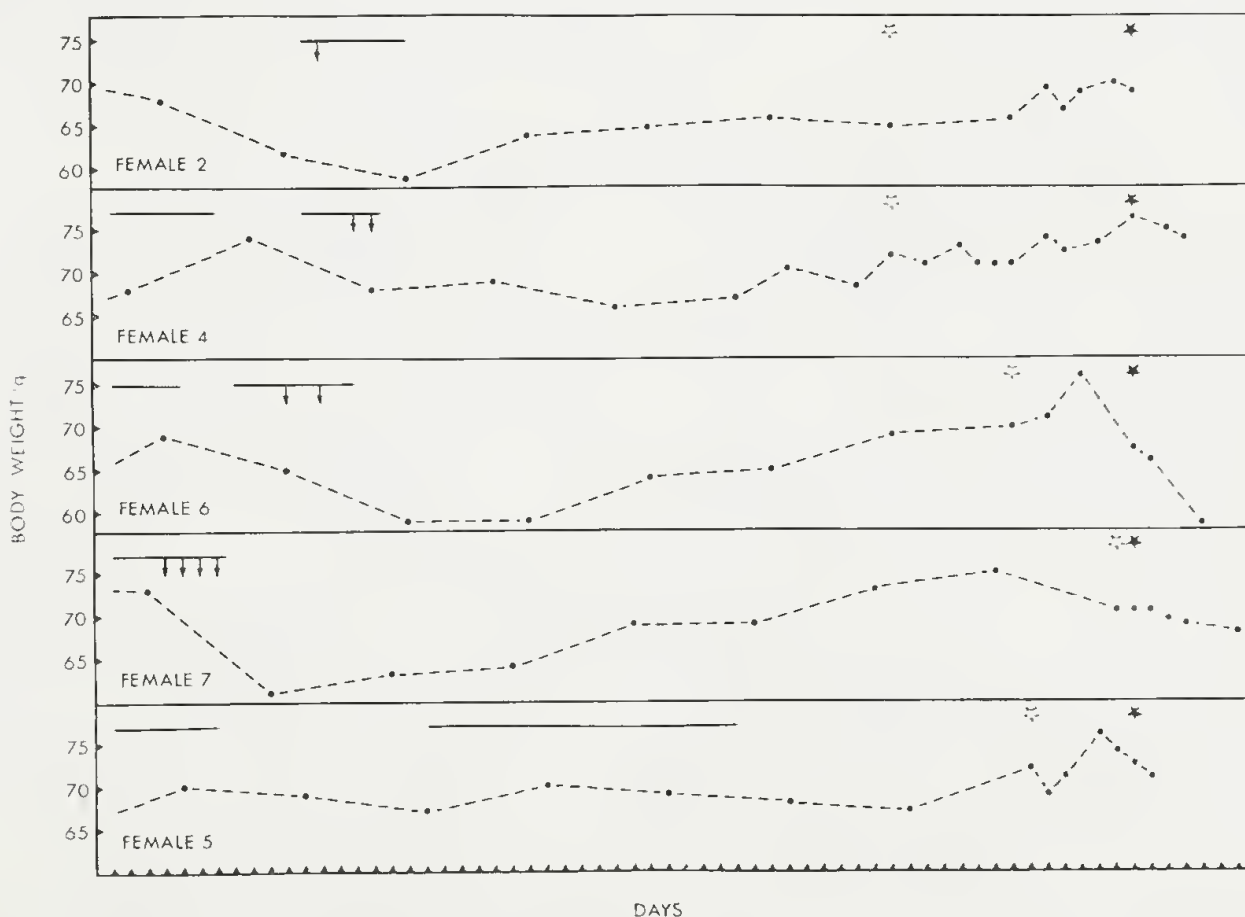


Figure 2.—Body weight of females during the breeding season, synchronised to the day of appearance of clear secretion in the pouch. The heavy line indicates the presence of a male in the cage with the female. ↓ copulation. ☆ pouch development first observed. ★ clear secretion in pouch.

13.—A salvage excavation in Devil's Lair, Western Australia

by C. E. Dortch* and D. Merrilees*

Manuscript received 22 June 1971; accepted 27 July 1971

Abstract

An open pit in the floor deposit of Devil's Lair (a small cave in the south west of Western Australia) which had been previously excavated, was filled to prevent further damage to a prehistoric archaeological site of considerable interest. Disturbed material found in the bottom and sides of this pit was first screened for animal remains and artifacts overlooked by previous collectors and a small volume of undisturbed deposit in one corner of the pit was excavated systematically. A report on animal remains and artifacts so recovered is given. The bottom of the deposit was not reached, but the upper 270 cm thickness appears to represent terminal Pleistocene and early Recent time, and contains artifacts and food remains left presumably by early Aborigines. Some of the animal remains recovered may have been left by "Tasmanian" devils or by owls. Mammal remains show no clearly recognizable climatic trends, but there is some suggestion that conditions were drier and/or warmer than the present during part of the time of accumulation of the deposit.

Introduction

Devil's Lair is a small cave in lithified aeolian dunes ("Coastal Limestone") in the Cape Leuwin-Cape Naturaliste region, Western Australia.

Much of Devil's Lair has a thick flowstone floor. In 1955 a party led by E. L. Lundelius breached this floor and excavated the underlying earthy deposit to a depth of about 120 cm. Although Lundelius was concerned mainly with the remains of mammals and made no mention of archaeological material in his published reports (Lundelius 1960, 1966), he did find artifacts and a piece of baler shell which we believe to have been transported by man. Subsequent collectors also recovered a few artifacts and one of these collectors makes published reference to "possible artifacts" (Cook 1960). Archaeological aspects of the site were reconsidered when one of us (D.M.) noticed a human incisor tooth among kangaroo teeth recovered from the deposit by the Lundelius party (Merrilees 1968b). This tooth has been described by Davies (1968).

Devil's Lair opens from the same doline as a much larger cave, Nannup Cave. Lundelius (1960, 1966) and Cook (1960) use the name "Nannup Cave" for Devil's Lair but except perhaps in considering its geological origin, Devil's Lair is better regarded as distinct from Nannup Cave. Nannup Cave is listed as W60 and Devil's Lair as W61 in the Western Australian Speleological Group's system of recording cave sites (P. J. Bridge, personal communication).

The excavation made originally by the Lundelius party had been irregularly widened and deepened by subsequent collectors in the intervening 16 years. We decided to clean out disturbed material left by these collectors, to

excavate systematically any undisturbed material within the boundaries set by previous excavators, to determine if possible the depth of the deposit, and then to fill the excavation to prevent further damage to the deposit.

Our party (see Acknowledgements) worked in the cave in December 1970, and this report summarizes our field observations and subsequent laboratory investigations, principally of the artifacts and faunal remains recovered, in what was essentially a salvage operation. Samples for sedimentological and palynological analysis were collected but have not yet been studied. We were unable to collect adequate samples of charcoal for dating.

We hope to make systematic excavations on a larger scale in Devil's Lair in due course, and to report our results in greater detail.

Our collections are preserved in the Western Australian Museum under catalogue numbers 70.12.1 to 70.12.1198, 71.1.1 to 71.1.283, 71.3.13 to 71.3.16, 71.6.1 and 71.437 to 71.472 (faunal); G13176, 13177 (lithological); A 21970 to 22028 and A 22113 to 22116 (archaeological).

For mammal names and taxonomic concepts, we follow Ride (1970).

The Excavation

The location of our excavation is shown in Fig. 1. It is referred to in our records as "Dortch Excavation, Trench A." We also cleaned out another smaller pit ("Small Excavation") left by previous excavators, and filled still another ("Shallow Excavation"), the positions of which are shown in Fig. 1.

Only the south west portion of our excavation yielded undisturbed deposit, the upper surface of which was detected about 16 cm below the flowstone floor of the cave. We followed this undisturbed material downward to a depth of 270 cm below the flowstone floor. At this depth, we considered that unsupported flowstone at the top of the excavation, and the irregular unsupported earth walls on the northern and eastern sides of the pit rendered further deepening of the pit dangerous.

We then drove iron rods into the floor in an endeavour to estimate the full depth of the deposit. These iron rods in places could be driven 170 cms below the floor of our excavation without encountering resistance. We had no iron rods of greater length, nor any other means of estimating the full depth of the deposit, which remains unknown but may be substantial. We then filled the whole pit, leaving plastic sheet and other markers of the limits reached.

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maximum duration of behavioural oestrus, 4 days. No changes in the pouch area similar to those occurring in *A. stuartii* during oestrus (Woolley, 1966a) were observed. About the time when mating occurred, body weight declined. Changes were first seen in the pouch area 30 to 52 days after the last copulation. The pouch area gradually enlarged and the sides thickened, and the pouch skin developed a granular appearance. Clear secretion, which accumulates around the base of the nipples of *A. stuartii* when birth of the young is imminent, or at the end of pseudopregnancy (Woolley, 1966a, b), appeared 44 to 53 days after the last copulation. Figure 2 shows the body weight, the occurrence of matings, the day when development of the pouch area was first observed and the day of appearance of clear secretion in the pouch of five females during the breeding period. The day of appearance of clear secretion in each of the females has been synchronised to simplify comparison of events. The periods during which a male was caged with each of the females are also shown.

None of the four females which were observed to mate produced pouch young and no young were found in the nesting material. Either the females failed to conceive, or young were lost during pregnancy or at parturition. Three of these four females were killed within 6 days of the appearance of clear secretion in the pouch and one ovary from each was sectioned. That ovulation had occurred was shown by the presence of corpora lutea in each ovary.

One female which was not observed to mate also showed development of the pouch area followed by the appearance of clear secretion. It can be seen from Figure 2 that this female was caged alone during the period when, from the time-relationships between mating and appearance of clear secretion in three of the other females, oestrus most probably occurred. It therefore seems likely that mating did not occur. If so, ovulation occurs spontaneously, for corpora lutea were present in the ovary.

Summary and General Conclusions

The dibbler appears to have only one breeding season per year. Unlike all other species of *Antechinus* so far investigated, which breed in winter or spring (Woolley, 1966, Wakefield and Warneke, 1967, and Taylor and Horner, 1970), the dibbler breeds in autumn. In the laboratory males showed spermatorrhea from early January to late April and matings occurred in March and April. No information is available on the occurrence of spermatorrhea in males in the field. There is an indication that breeding in the field occurs at approximately the

same time of the year as in the laboratory, since wild-caught female 3 gave birth to young in April.

No young resulted from the matings which occurred in the laboratory. However, if the appearance of clear secretion around the nipples can be equated with the end of pregnancy, or pseudopregnancy (as in *A. stuartii*), an estimate of the gestation period in *A. apicalis* can be made. The period from the end of behavioural oestrus to the appearance of clear secretion varied from 44 to 53 days in four females.

The young of female 3 were dependent on the mother for approximately 4 months. They reached sexual maturity in the breeding season of the year following that in which they were born, when they were about 10 or 11 months old.

Females may breed in more than one breeding season. Female 3 appeared to have reared a litter before capture in 1967, and another litter was reared in captivity.

The evidence available suggests that males also may breed in more than one breeding season. Male 1 was probably reproductively mature in 1967 and was coming into breeding condition again early in 1968.

Acknowledgements

The author is grateful to Dr. W. D. L. Ride, Director of the Western Australian Museum, and to the Department of Fisheries and Fauna, Western Australia, for the opportunity to study these rare marsupials. The mites were identified by Mr. R. Domrow, Queensland Institute of Medical Research.

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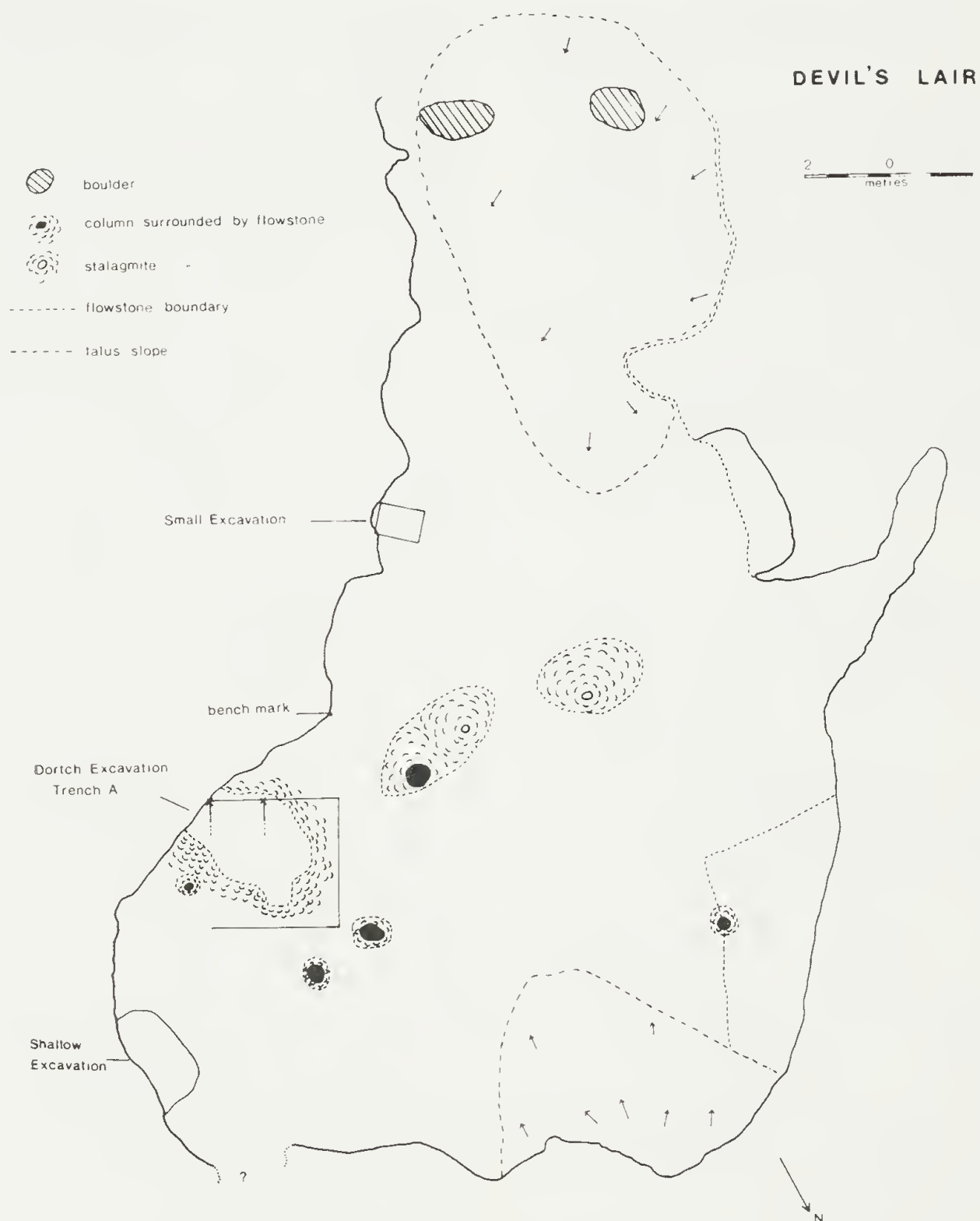


Figure 1.—Floor plan of Devil's Lair, Cave W 61, Cape Leeuwin-Cape Naturaliste region, Western Australia.

DEVIL'S LAIR Trench A1

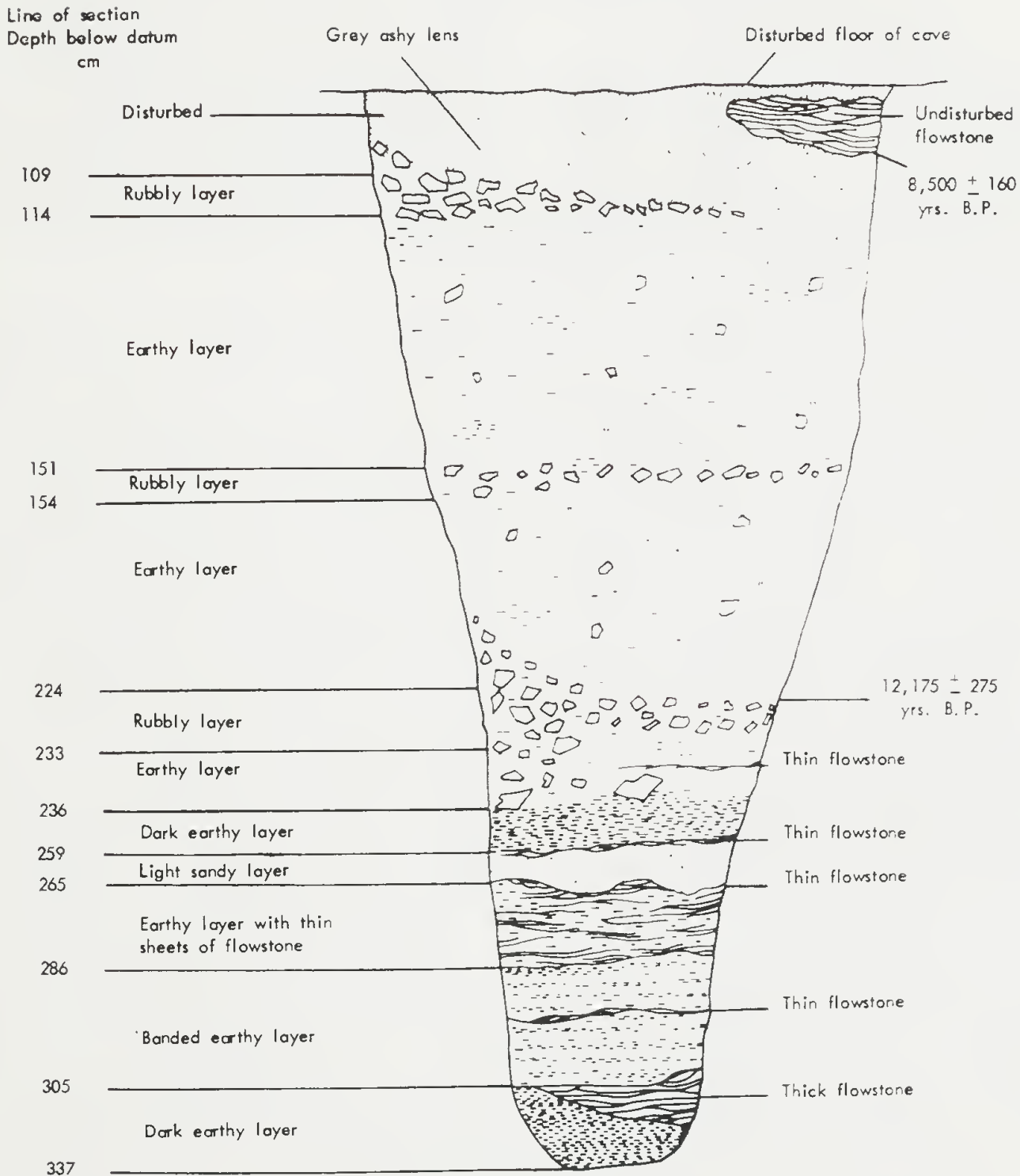


Figure 2.—South west section of undisturbed cave floor deposit, Trench A1, Dortch Excavation, Devil's Lair. The "line of section" depths were measured vertically on the north east face of the trench, and correspond only approximately with the actual depths of the layers shown above. The stratigraphic correspondence of the layers shown with those in the line of section is exact. The approximate stratigraphic positions of the radio-carbon dates reported by Lundelius (1960) are shown on the right.

Fig. 2 summarizes our field observation of the section of undisturbed deposit revealed in the south western corner of our excavation ("Trench A1" in our records) and Fig. 3 shows this corner with the excavation nearing completion. Only in this corner could we obtain vertical faces of undisturbed deposit in which to study the stratigraphy. The irregular outlines of the remainder of the excavation were preserved because we wished to avoid further encroachment on the deposit pending our choice of a suitable position for later systematic excavation.



Figure 3.—Trench A 1, Dortch Excavation, Devil's Lair, showing walls of stratified undisturbed cave floor deposit. The ranging pole shows one foot divisions. The vertical face lying between the ranging pole and the lamp is that represented in Fig. 2. The stalagmite shown separately in Fig. 4 is that shown close to the right hand wall in this photograph. The excavation was carried downward about 70 cm. after this photograph was taken.

We recorded depths below an arbitrary cave datum, in a line of section arbitrarily chosen, and it is these depths which are recorded on the left in Fig. 2 and Table 1, as well as in

our field notes and on the labels of our specimens. Fig. 2 shows a face about 90 cm removed from this line of section. The layers dipped at low angles and there were irregularities in the layer boundaries. Hence the line of section depths do not correspond exactly with the layers shown in Fig. 2.

Age of the Deposit

Two radiocarbon dates are reported by Lundelius (1960) for his excavations in Devil's Lair. Both were determined on charcoal samples. The uppermost sample came from "immediately under the travertine floor" which would correspond stratigraphically to a depth of about 100 cm in our line of section. The date recorded is $8,500 \pm 160$ yrs B.P. (0-654).

Lundelius' lower dated sample came "from a depth of four feet", which would correspond stratigraphically approximately with a rubbly layer extending from 224 to 233 cm deep in our line of section. This date was $12,175 \pm 275$ yrs B.P. (0-658). (Date numbers—E. L. Lundelius, personal communication.)

Lundelius (1960) comments that his dates show "a slow rate of accumulation of sediment within the cave". Alternatively, the lack of change in character noted by Lundelius in the upper part of the deposit, which we confirm, might mean that the sediment accumulated rapidly and that the younger dated sample represents material which accumulated on a surface of long standing, prior to the formation of a thick flowstone. We found no such surface, but the uppermost part of our section was disturbed, presumably by previous collectors burrowing under the flowstone.

There is evidence from the lower part of our excavation of at least one lengthy pause in sedimentation. At a depth of about 208 cm below our arbitrary datum, our excavation in undisturbed material revealed the top of a stalagmite. As excavation proceeded, this stalagmite was uncovered to a depth of 265 cm, where it was found to originate on a thin flowstone (see Fig. 2) marking the top of one of our stratigraphic units, an earthy layer containing very thin discontinuous sheets of flowstone. This layer, and the one below it, down to a depth of about 305 cm below datum, contained ill defined stalagmitic masses directly below the well defined stalagmite described above. It seemed as though a drip system had persisted in the cave for some time. At first, this drip system produced stalagmitic masses some 10 cm in height (e.g. specimen G 13177), but these were buried by incoming "cave earth". A more coherent flowstone than usual then appears to have sealed this earthy layer, and sufficient time appears to have elapsed for the same drip system to produce a stalagmite nearly 11 cm in diameter at its base; this stalagmite (specimen G 13176) is shown in Fig. 4.

TABLE 1

Minimum numbers of individuals of the mammal species and other vertebrates listed, found in situ in Devil's Lair, 1970

Depth below datum in line of section	Approximate stratigraphic position of previously dated samples	Minimum number of vertebrate animals represented per cubic metre of deposit	Species identified																Bat	Bird	Reptile	Artifacts									
			<i>Dasynus geoffroyi</i>	<i>Phascogale tapoatafa</i>	<i>Antechinus flavipes</i>	<i>Smithopsis murina</i>	<i>Sarcophilus harrisi</i>	<i>Isodon obesulus</i>	<i>Perameles</i> cf. <i>P. bonguiville</i>	<i>Trichosurus vulpecula</i>	<i>Pseudochelone peregrius</i>	<i>Cercartetus concinnus</i>	<i>Potorous tridactylus</i>	<i>Bellongia penicillata</i>	<i>Bellongia lesueur</i>	<i>Petrogale penicillata</i>	<i>Macropus eugenii</i>	<i>Macropus irma</i>				<i>Macropus fuliginosus</i>	<i>Setonix brachyurus</i>	<i>Pseudomys prueensis</i>	<i>Pseudomys albocinctus</i>	<i>Pseudomys shortridgei</i>	<i>Notomys</i> cf. <i>N. mitchelli</i>	<i>Rattus fuscipes</i>			
109	8,500 ± 160 yrs B.P.	1,030	1			1	2	1	1	1	1	2	2	2	2			1	1		1	1		1	3	2				p	
114		350	5		14	2	9	2	4	4		7	13	7	2	2		2	2		7	4		1	11	1	1	11		p	
151		1,070	1	1	6			1	1	1	1		2	1	1	2					2	1	1	1	2	2				p	
154		310	9	1	1	15	2	10	2	9	12	4	3	12	14	7	2	1	6	5		13	5	5	5	20	1	3	2		p
224	12,175 ± 275 yrs B.P.	380	1		4		1		1	1	2		2	1				1	1	1	3	2		6	1	1	2			p	
233		700	1		1	2	1						2	2	1					1	1	2	1	1							
236		120	1			3		1		1	2	1		1	1			1			1	1	1	1	6			1			
259		2,040			2	2				1	1	2		1				1			2	2	2	2	17		2				
265	70	1										1		1						1	1			1	1	1	1	1			
286	280				5		1	1	1	1								1	1	2	1	1		6		1	2				
305	290		2	3	2		2	1										1	1	2	2	3		10	2	1	2				
337	(Bottom not reached)																														



Figure 4.—Stalagmite G 13176 found buried in undisturbed floor deposit, Devil's Lair. Base was part of thin flowstone 265 cm below datum, top was embedded in earthy layer 208 cm below datum. Projecting lip about 11 cm above base represents part of thin flowstone capping same "light sandy layer" as shown in Fig. 2.

This stalagmite grew in stages to a height of 57 cm and when we uncovered it, it received frequent periodic drips, enough to wash the top clean, as shown in Fig. 3. Thus the same drip system appears to have functioned right up to the present day, although it may have been intermittent.

Some mechanism must have prevented the growth of this stalagmite above the 208 cm level. The likely mechanisms appear to be either drying up of the drip system or influx of "cave earth" in sufficient quantity to bury the stalagmite deeply. If the latter, the burial appears to have been rapid because the top of the stalagmite is smoothly rounded and shows no contamination by "cave earth" and because there were no stalagmitic masses in the undisturbed

deposit vertically above G 13176. There may have been stalagmitic masses in the uppermost parts of the deposit prior to its disturbance. Indeed there may have been a stalagmite on the thick flowstone which originally capped the deposit but which was removed before our excavation began.

This interpretation (rapid burial of stalagmite G 13176) reinforces the suggestion made above that the upper part of the deposit may have accumulated rapidly.

We have no data on the rate of growth of stalagmites in Devil's Lair at any given time, and in any case, this rate of growth probably differs at any one time from one point to another only a few centimetres away, presumably depending on the supply of water from the roof. But the growth of a substantial stalagmite may represent some considerable pause in sedimentation in the cave. Perhaps significantly, resumption of sedimentation is marked by our most distinctive stratigraphic unit, a light coloured, sandy layer, conspicuously rich in the remains of small mammals (the layer shown in Fig. 2 as extending from 259 to 265 cm below datum).

We found no other clear evidence of such pauses in sedimentation, but we excavated only a very small volume of undisturbed deposit. It is reasonable to suggest that each flowstone layer revealed in our excavation (see Fig. 2) represented a pause in sedimentation, even though most of these flowstone layers were very thin (about 1 cm thick).

Thus, accepting the dates reported by Lundelius as applying approximately to our excavation, and accepting that each flowstone recorded by us marks some pause in sedimentation, we suggest that the deposit excavated by us represents terminal Pleistocene and early Recent time.

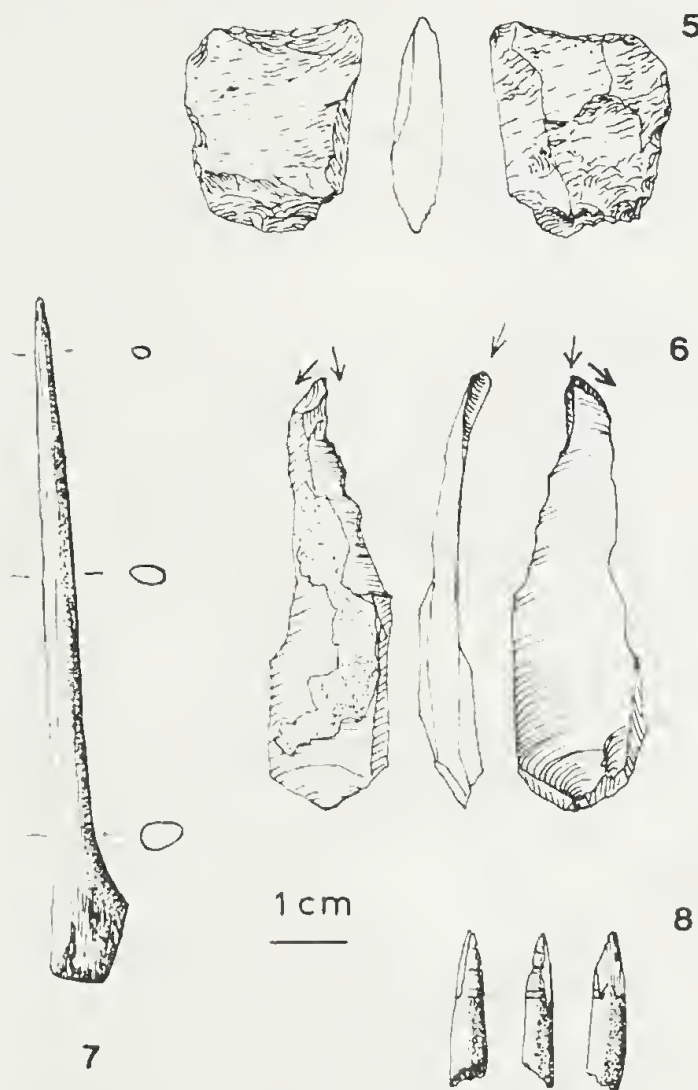
Artifacts

We found stone and bone artifacts, charred bone, fragments of bones which could have been broken by man, and bones and teeth which appear to be artificially incised. This material was confined to the upper 140 cm of the deposit (Table 1). Previous excavators also found such items, including the baler shell and human incisor tooth mentioned by Merrilees (1968b), a fragment of fresh water mussel shell (70.63) collected by D. L. Cook in 1959 or 1960, stone artifacts collected at various times, and the dentary of a rock wallaby (70.6.105) with deep, narrow, transverse cuts on the incisor, collected by K. Pearce-Shorten and others in 1970.

Fourteen chert or quartz flakes were excavated by us from the undisturbed part of the deposit, and six more were recovered by screening the disturbed material. In addition, many fragments of calcrete were recovered, both from disturbed and undisturbed material, which conceivably could be artifacts. Some resemble choppers or rough cores (e.g. A 22018), while others (e.g. A 22007) could be flakes. It is difficult to decide whether or not these calcrete objects are indeed artifacts because most of them have been corroded by ground water.

A quartz flake with bipolar shattering (A 21976), of the type variously referred to in Australia as a fabricator (e.g. by McCarthy 1968) or a scalar core (e.g. by White 1968) and in France as a *pièce écaillée* (e.g. by Sonnevile-Bordes and Perrot 1956) is shown in Fig. 5; this came from undisturbed deposit (150 cm below datum).

No other formal tool types such as geometric microliths, retouched points, scrapers or adze-flakes were recovered by us either in undisturbed or disturbed material from the excavation site, and so far as we know, previous excavators did not recover any such tools. However, we did find a dihedral burin made on a small blade (A 17558a) cemented to the flowstone surface of the cave floor about 3 m from our excavation; this is shown in Fig. 6.



Figures 5-8.—Artifacts from Devil's Lair. 5.—Quartz flake A 21976 with bipolar shattering, from undisturbed deposit about 150 cm below datum. 6.—Burin A 17558a, found cemented to the flowstone floor of the cave near "Small Excavation". 7.—Bone point A 21983, from undisturbed deposit 151 to 154 cm below datum. 8.—Lower incisor A 22025a of a wallaby with transverse incisions; recovered during screening of disturbed material; probably lay about 100 cm below datum.

Bone artifacts include a point or awl about 8½ cm long (A 21983) made from the fibula of a wallaby. This was found *in situ* and is shown in Fig. 7. Historical accounts (Grey

1841 p. 266, Moore 1842 pp. 31-32, 78, Hammond 1933 p. 31) of the use of tooth and bone tools by Aborigines in south western Australia include several uses for which A 21983 would be appropriate. It might have been used to make holes in kangaroo skins preparatory to sewing them together for use as cloaks or bags, or as a toggle to fasten the neck of a skin cloak, or to drill holes in the butts of spears to fit the peg of the spear thrower, or to pierce the septum of the nose to accommodate a nose bone, or as the nose bone itself, or to aid in the extraction of teeth.

Many bone splinters and fragments were smoothly rounded or pointed at the ends, suggesting they might have been used as tools. However, Brain (1967) has shown that "bone pseudo-tools" can be produced from scraps of bone broken by humans, further broken by their dogs, left lying on sandy surfaces, and subjected to trampling by men and goats. It is conceivable that a somewhat similar process could have affected bones in Devil's Lair, broken initially by men, then by dogs or devils, then trodden by men and perhaps by devils or wallabies into sandy surfaces. Consequently we are reluctant to describe most of the bone splinters collected as tools.

However, some of these bone fragments and some wallaby lower incisor teeth carry narrow relatively deep incisions which appear to be man made. For example, wallaby incisor A 22025a, shown in Fig. 8, might have been hafted for use as a tool. Moore (1842 p. 54) reports that among Aborigines in the south west of Western Australia, a large kangaroo incisor sometimes was inserted in the gum handle of a spear thrower "for the purpose of scraping anything, as the points of spears &c." Nind (1832 p. 30), in his description of the butchering of kangaroos by the Aborigines of King George Sound, reports "The first operation is to extract the front teeth of the lower jaw, which they use to sharpen the spear points; . . ."

We know of no historical records for the region of the splitting and smashing of long bones or of the use of such bones or bone splinters as tools, though Ord (1879 p. 10) records that there was much use of kangaroo bone "for domestic purposes". It is possible that some femur fragments from Devil's Lair, such as A 21999 or A 22028a represent deliberate break-aggs to extract marrow.

Some of the bone fragments from Devil's Lair (e.g. A 21993) are charred, and while such charring might result from bush fires acting on partly decayed carcasses or on bare bones lying outside the cave and subsequently washed in, it is equally likely to result from deliberate cooking of butchered carcasses either outside or inside the cave, or from the burning of bone fragments regarded as refuse, as described by Hammond (1933).

The piece of baler shell mentioned above (Chicago Natural History Museum specimen PE 11150) represents the rather rare gastropod *Cottonia nodiplicata* (Cox, 1910) (B. R. Wilson, personal communication).

We found no human skeletal remains, either in the undisturbed deposit we excavated nor in the disturbed material we screened.

Fauna

Our excavation in undisturbed deposit confirmed what has been suggested from the findings of previous workers, namely that the Devil's Lair deposit is faunistically rich, especially in mammals, but that it contains no examples of the large extinct marsupials such as *Sthenurus* or *Zygomaturus* known from other deposits in the Cape Leeuwin-Cape Naturaliste region, such as Mammoth Cave (Merrilees 1968b) or Labyrinth Cave (Merrilees 1969). Faunistic data for Devil's Lair are set out in Table 1.

There are some differences between the species listed in Table 1 and those listed by Lundelius (1960) and Cook (1960). Some of these are merely differences in name, resulting from the recent reappraisals of species limits noted by Ride (1970), for example our use of *Potorous tridactylus* to embrace specimens formerly assigned to the more narrowly conceived "species" *P. gilberti*. But we differ from Cook (1960) in ascribing our *Sminthopsis* specimens to *S. murina* rather than to *S. crassicaudata* and we add some new records, namely *Antechinus flavipes*, *Cercartetus concinnus*, *Macropus eugenii*, *Notomys* cf. *N. mitchelli* and *Pseudomys praeconis*.

Other additions based on specimens recovered from our screening of disturbed material are noted below.

The most barren layer of undisturbed deposit excavated by us yielded vertebrate remains equivalent to 70 individual animals of all sizes per cubic metre, and the richest layer, 2040 individuals per cubic metre; both of these layers were in the lower part of our excavation. Layers which could be described as "rubbly" were richer in vertebrate remains than the remaining layers which could be described as "earthy". Towards the top of the deposit remains of vertebrates of about the size of the introduced rat (*Rattus rattus*) were present in numbers comparable with vertebrates of larger size; but towards the bottom of our excavation there was a predominance of small animals, in the proportions of about 17 small to 1 large vertebrate in the richest layer. Mammals greatly predominated over other vertebrates at all levels, comprising 75% of the total vertebrate individuals in the most barren layer mentioned above and 94% in the richest. Murids were the most abundant mammals, with at least 230 individuals represented in undisturbed deposit, followed by macropodids (at least 117 individuals) and dasyurids (at least 97 individuals).

Some of the mammal species represented appear to have become extinct in the Cape Leeuwin-Cape Naturaliste region in prehistoric time, though persisting elsewhere in Australia long enough to have left historic records in the form of museum specimens. For example, *Sarcophilus harrisii* (the "Tasmanian" devil) was represented by remains of at least 7 animals, all from the upper parts of our excavation; this species appears to have been confined to

Tasmania in historic time. The most common macropod in the deposit was the rat kangaroo *Bettongia lesueur*, and the next most common was the rock wallaby *Petrogale penicillata*, neither of which is recorded in the Cape Leeuwin-Cape Naturaliste region in historic time, though both species still live elsewhere in Western Australia. Of the two bandicoot species represented in the deposit, the more common was the short nosed bandicoot (*Isodon obesulus*) which still lives in the region. The less common species in the deposit (a species of long nosed bandicoot, *Perameles*) is not known from the region in historic time, though it or a similar species still persists elsewhere in Western Australia, and it is known from other fossil deposits in the region (Merrilees 1968a). The number of individuals of *Macropus fuliginosus* entered in Table 1 may be too high, as the large bones of one animal may have become distributed over several layers by what White (1970) calls "treadage and scuffage".

Most mammal species present at all were present at most levels in our excavation, as shown in Table 1. However, trends were discernible in the depth and therefore age distributions in a few species. *Antechinus flavipes* was present in small numbers, but only in the lower parts of the deposit, as also was true of *Cercartetus concinnus* and *Potorous tridactylus*. On the other hand, *Sarcophilus harrisii*, *Macropus eugenii* and *Macropus irma* were present in small numbers but only in the upper parts of the deposit. *Petrogale penicillata* was well represented in the upper but not present in the lower part of the deposit; this species is not recorded from the older Mammoth Cave deposit (Merrilees 1968b), so it would appear to have arrived in the region before 12,000 years ago, but not long before.

It is difficult to infer climatic changes from the few cases of changing faunal distribution with depth in our excavation, and it seems likely that chance plays some part in the distribution. For example, the total number of specimens of *Potorous tridactylus* is so low (representing perhaps 4 individuals) that its absence from the upper parts of the deposit may have no great significance, especially since its remains are common in the surface litter of bones present in other caves nearby. Indeed, it is the paucity of *Potorous* specimens that requires explanation rather than their absence from particular levels. Some of the *Potorous* specimens (e.g. 70.12.791) are small relative to specimens from other caves in the region. Another species represented only by very small numbers (4 individuals) is *Phascogale tapoatafa*, and this is present both in upper and lower parts of the deposit.

Table 1 lists a seemingly incongruous mixture of species like *Bettongia lesueur*, *Perameles* cf. *P. bougainville*, *Pseudomys albocinereus* and *Notomys* cf. *N. mitchelli* which in historic time appear to have been typical of rather dry environments, and others like *Potorous tridactylus*, *Setonix brachyurus* and *Pseudomys shortridgei* apparently more characteristic of wetter environments. Some of this seeming incongruity may

arise from the geographical setting of Devil's Lair. At present, and perhaps in the past, the cave lies near a boundary between forest and a coastal zone of heath-like and shrubby vegetation on sand dunes. Even the forest is not uniform, part of it growing on laterite deposits shallowly mantling the crystalline basement rock, and part of it growing on a thicker mantle of "Coastal Limestone". Running streams and permanent swamps occur in the former parts, while the latter are characterized by sub-surface drainage.

Thus one would expect a sample of the mammals living within a few kilometres of Devil's Lair at present to include representatives of rather dry and rather wet environments. Some of the specimens mentioned below, however, seem to go beyond this expectation and to suggest that there were phases of drier and perhaps warmer climate during accumulation of the deposit excavated.

Cook (1960) records the ghost bat (*Macroderma gigas*—specimen 60.10.21) from the upper part of the deposit; this species appears to have lived only in arid or tropical parts of Australia in historic time (Ride 1970), and the nearest locality of any specimen, fossil or modern, in the Western Australian Museum collection, is in the Wanneroo district, near Perth (specimen 68.5.9).

Our record of *Notomys* is the only record of this genus, modern or fossil, for the Cape Leeuwin-Cape Naturaliste region, despite the fact that caves are numerous, and surface litter in many caves and excavations in some have yielded abundant fossil and sub-fossil remains (Merrilees 1968b). We found specimens *in situ* representing at least 9 individuals of *Notomys* cf. *N. mitchellii*, and additional specimens in disturbed material, so that possibly the occurrence has some climatic significance. It may indicate drier conditions at some time in the past than obtain now.

A small fragment of the dentary of a very young animal (70.12.1132) found by us in disturbed material has not been identified with confidence, but may represent the brown hare-wallaby *Lagorchestes leporides*. This is recorded in historic time from western New South Wales, eastern South Australia, and north western Victoria (Ride 1970).

A single worn canine tooth (70.12.202), also found in disturbed material, appears to represent the dingo (*Canis familiaris*). Unless this specimen came from surface litter accidentally incorporated in the excavated material its age is apparently no less than about 8,500 years, making it the oldest record of the species for the whole continent (cf. McCarthy 1970).

In addition to the mammal remains described above, those of bats, small birds, lizards, snakes, snails and insects were recovered during our excavations, but except for the snails (see below) have not been examined in detail.

Discussion

We have no doubt that the Devil's Lair deposit has an archaeological component, at least in the upper parts excavated, and it may prove

to be of considerable archaeological interest when an adequate sample of undisturbed material can be excavated carefully.

The undisturbed material excavated by us was too small in volume to enable us to decide whether the deposit represents a human occupation site or whether the artifacts were washed in or brought in by devils, emus or other animals. We found no waste material from stone working in the area excavated, but this area was at the back of the cave and may never have received enough light for stone working to be carried out. On the other hand the cave may have served as a temporary camp for use in bad weather or by groups engaged in some specialized activity.

The absence of geometric microliths and backed blades is worthy of note. Surface finds of these tools in areas immediately to the north and east of the Cape Leeuwin-Cape Naturaliste region indicate that geometric microliths and backed blades were used in south western Western Australia in times unknown. Neither of these tool forms is known to occur in the Cape Leeuwin-Cape Naturaliste region. This absence may be due as much to the lack of systematic collecting of surface material as to a real absence of those tool forms in this area. At the same time, if one refers to the dating sequences of the industrial developments in other parts of Australia (e.g. Mulvaney 1969, Lampert 1971, Lampert in Mulvaney and Golson 1971), their absence from a deposit which is apparently at least eight thousand years old could indicate that the site was occupied prior to the development or the introduction of these tool forms in the region.

Devil's Lair is at present nearly 5 km from the sea shore, and the excavated parts of the deposit apparently represent times of lower sea level and an even more distant shore line than the present. Thus it is not surprising that remains of fish, marine mammals and marine shellfish have not been found in the deposit, except for the piece of baler shell mentioned above, which may be the remains of a water carrier, not of an item of diet. Possibly the Aborigines whose artifacts were found in Devil's Lair did include marine animals in their diet, but if so, did not transport them as far inland as Devil's Lair. However, it is also possible that these people did not normally eat marine animals.

The faunal remains listed for the upper part of the deposit, which also yielded artifacts, are consistent with the view that they represent Aborigines' food remains. Kangaroos, wallabies, possums, rats and lizards are all recorded as foods favoured by Aborigines in the south western part of Western Australia at the time of the European occupation (Grey 1841).

According to Lundelius (1960, 1966) the upper part of the deposit excavated by him represented the floor deposit of a *Sarcophilus* den on two of his major criteria (presence of *Sarcophilus* remains and presence of remains which can reasonably be ascribed to *Sarcophilus* prey). The third of his criteria (presence of coprolites

which could reasonably be ascribed to *Sarcophilus* subsequently has been met also, for example in specimen 68.4.171.

Nevertheless we suggest that the bone component of the deposit is not entirely, perhaps not primarily, the leavings of *Sarcophilus*, but at least in part the leavings of man. Both *Sarcophilus* and man were present in the area, both take small and medium sized animals as prey, and both leave behind broken bones. But in addition, man may be expected to include some of the larger mammals such as *Macropus irma* (the western brush wallaby) or *M. fuliginosus* (the western grey kangaroo) as prey, and to leave behind bone fragments charred in cooking fires, either during the cooking process or after the bone fragments were discarded. It is possible that *Sarcophilus* as it is represented in the Devil's Lair deposit, was prey, not predator.

We have no certain evidence of charring of *Sarcophilus* bones, but numerous fragments of other bones were charred, and readily identifiable fragments of three mammal species were so charred (*Bettongia penicillata*, *Trichosurus vulpecula* and a large *Macropus* presumably *M. fuliginosus*—specimens A 22114-6 respectively).

Guiler (1970) suggests that devils (*Sarcophilus*) at present "live successfully in close contact with human settlement and activity . . .", and they may have been scavenging camp followers of the Aborigines, at least before the introduction of the dog. Thus Devil's Lair might have served intermittently as the camp site of an Aboriginal group visited from time to time by scavenging *Sarcophilus*, but at which captured *Sarcophilus* individuals were occasionally cooked and eaten. In the intervals between successive human occupations, it might have served as a *Sarcophilus* lair. It might not be easy to choose between these alternatives even after large scale, systematic excavation of the deposit.

We suggest that the upper part of the deposit, including all that excavated by Lundelius, represents, in part, food remains and other debris of human predators. Artifacts do not occur in the lower parts of the deposit excavated by us, nor does *Sarcophilus*. It is in these lower parts that small mammals greatly predominate over large ones. Some other smaller predator appears to be involved in the lower parts of the deposit, and this might be *Sarcophilus* or *Dasyurus* or an owl such as the masked owl (*Tyto novaehollandiae*) which still occurs in the region (Mees 1963). *Dasyurus* or *Tyto* individuals initially occupying the cave may have been driven out later by *Sarcophilus*, permanently or intermittently. Again, if *Sarcophilus* or *Canis* arrived late in the region, they might have altered the relative abundance of various prey species. If a predator as small as an owl was responsible for most of the small mammal remains at any level, some other agency must have been responsible for remains as large as those of *Macropus fuliginosus*.

The deposit appears to us to comprise mainly material washed or fallen into a cavity which was once much larger than the existing one.

If this is so, remains of large animals dying or being killed outside the cave might well become mixed with remains of small animals accumulating beneath an owl roost in the cave. Indeed, such processes might have continued throughout the time of deposition, with intermittent occupation by human beings and/or "Tasmanian" devils in the later stages.

Further support for the concept of human occupation of the area comes from a consideration of the land snail remains recovered. Shells of *Austrosuccinea* and *Luinodiscus* were abundant, but those of the larger *Bothriembryon* were uncommon, a quite different situation from that in the nearby Strong's Cave, which could never have been easily accessible to human visitors. *Bothriembryon* is at present common in dolines in the Cape Leeuwin-Cape Naturaliste region, but less common on the surrounding forest floor. Disturbance of the topsoil and the vegetation of the doline by human trampling, digging and burning would militate against *Bothriembryon* much more than against the smaller *Austrosuccinea* or the tiny *Luinodiscus* which could continue to occupy rocky recesses in the walls of the doline (G. W. Kendrick, personal communication).

If the upper parts of the deposit do indeed represent the refuse of human groups, and do not contain remains of *Sthenurus*, *Zygomaturus* and other such large animals, then presumably these large animals had already become extinct in the region, as Jones (1968) has postulated.

Acknowledgements

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Mrs J. K. Porter prepared the plan and Mrs V. Mackaay took the photograph here reproduced as Figs 1 and 3 respectively, and in addition, Mrs Porter played an active part in the study of our collection. Mrs P. Kaill prepared Figs 1 and 2 for publication and Mrs G. E. Handley typed the manuscript. We are grateful for these contributions and also for identifications of and advice on dasyurids, murids and land snails given by Messrs M. Archer, A. Baynes and G. W. Kendrick respectively.

The Augusta-Margaret River Tourist Bureau, in whom this and other caves are vested, kindly agreed to let us work in the cave, and Mrs M. Dortch and Messrs W. C. Dix, T. W. Doyle and M. J. Yates gave us valuable assistance at the site.

We are grateful to Mrs S. J. Hallam and Dr D. J. Kitchener for their criticisms of the text.

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14.—Host range and symptoms in Western Australia of the gall rust, *Uromycladium tepperianum*

by Janette Gathe*

Communicated by R. N. Hilton

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Abstract

Sixty named host species of *Uromycladium tepperianum* (Sacc.) McAlpine collected during 1962, 1963 and 1964 in the south-west of Western Australia or noted from herbarium specimens are recorded for the first time, bringing the total of known hosts from 58 to 118. The possibility of extending the host range by artificial inoculation is indicated. For indigenous south-west Western Australian host species, the parts of the plants affected are indicated, together with gall type.

Introduction

The rust genus *Uromycladium* was erected by McAlpine in 1905 and included seven microcyclic species. No additional species have been described. McAlpine described the characteristic feature of the genus as "teleutospores borne in clusters, composed of one spore and cyst or two or more spores with or without a cyst, depressed globose and attached to a branched sporophore." The branched sporophore and sterile cyst are most unusual features in the rust teliospore. Of the seven known species of *Uromycladium* only two, *U. notabile* and *U. tepperianum*, induce gall formation in their hosts. *U. tepperianum* was originally described, illustrated and named as *Uromyces tepperianus* by Saccardo (1889), who thought that the unicelled teliospores were borne singly on unbranched sporophores. McAlpine (1905 p. 310) discovered that they were borne in clusters of three on branched sporophores. The rust is autoecious upon *Acacia* and *Albizzia* species and although the host range has been studied extensively in Eastern Australia, only a few hosts have hitherto been recorded in Western Australia. This paper records the results of a survey of the host range of *U. tepperianum* in the South-west botanical province of Western Australia. The data presented here were obtained during collecting trips over the years 1962-64 and during the course of study of all available material in the Western Australian Herbarium and the University Botany Department.

Host Species

U. tepperianum is parasitic on species of the two closely related genera *Acacia* and *Albizzia*. Within the genus *Acacia* it has a wide host range, a count made from the publications of various Eastern States' authors yielding fifty

seven Australian species up to 1965 of which ten of the records are from Western Australia (nine species indigenous to that state; one species, *A. cyclopis*, A. Cunn. that occurs also in the Eastern States).

It has also been recorded on *Albizzia montana* Benth. from Java (McAlpine 1906 p. 112), so that the total number of recorded hosts prior to this study was fifty eight.

Table 1 lists the species recorded during this survey as hosts of *U. tepperianum*.

The number of natural Western Australian hosts of *U. tepperianum* is seventy, of which sixty nine are species of *Acacia*. Sixty of the seventy are new records. This represents approximately one quarter of the *Acacia* species occurring in the State. The occurrence of *Albizzia distachya* as a host is of interest because it is the first Australian record, and only the second species of this genus which has been observed to be infected by this rust.

Artificial Inoculation

Artificial inoculation would extend the host range still further, for example, two species: *Acacia brachystachya* Benth. and *A. microneura* Meissn., which have not been recorded previously as hosts were found to be susceptible to *U. tepperianum* under experimental conditions. Mature, uninjured phyllodes of these species were sprayed with water and then inoculated with mature teliospores of *U. tepperianum*. The inoculated phyllodes were placed in an erect position with their cut ends immersed in water and kept under humid conditions. Infection occurred and pycnia developed on the phyllodes of *A. brachystachya* Benth. within eight days, and *A. microneura* Meissn. within fifteen days, after inoculation. However, these species have not been found infected in the field, and are not entitled to inclusion in the host list. The phyllodes of another species, *A. longifolia* Willdt., which has been introduced into Western Australia from the East, developed pycnia eight days after inoculation. It has been recorded as a host in Eastern Australia (McAlpine 1906 p. 111) but infected trees were not found in Western Australia.

Thirteen species not recorded as hosts proved resistant on inoculation. These are *A. andrewsii*, W. G. Fitzg. *bidentata* Benth., *crassiuscula* Wendl., *cuneata* Benth., *dentifera* Benth., *dictyophleba* F. Muell., *lanuginosa* C. A. Gardn.,

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TABLE 1

Species recorded as hosts of *Uromycladium tepperianum* in Western Australia with gall-type indicated.

	Other States in which species found	Stem	Phyllode	Peduncle	Inflor- escence	Fruit
<i>Acacia acanthoclada</i> F. Muell.	S.A., Vict.	G				
<i>A. aciphylla</i> affin. Benth.		G				
<i>A. acutata</i> W. V. Fitz.		G				
* <i>A. acuminata</i> Benth.		G	G			
<i>A. acutata</i> W. V. Fitz.		G				
<i>A. ancistrophylla</i> C. Andrews		G	G			
<i>A. beauregardiana</i> Ewart and Sharman		G	G			
<i>A. biflora</i> R. Br.		G				
* <i>A. birenosa</i> DC.		G				E
<i>A. blakelyi</i> Maid.		G				
<i>A. brachyphylla</i> Benth.		G				
<i>A. cochlearis</i> (Labill.) Wendl.		G				
<i>A. cochlocarpa</i> Meissn.		G	G			
<i>A. colletioides</i> A. Cunn. ex. Benth. var. <i>nyssophylla</i> (F. Muell.)	S.A., Vic., N.S.W.	G				
Benth.						
<i>A. cometes</i> C. Andrews		G				G
<i>A. coolgardiensis</i> Maid.		G				
<i>A. cupularis</i> Domin		E				
* <i>A. cyanophylla</i> Lindl.		G	G	G		G
* <i>A. cyclops</i> A. Cunn. ex G. Don	S.A.	No galls found by present author				
<i>A. dariesioides</i> C. A. Gardn.		G				
<i>A. decipiens</i> (Koen.) R. Br.		G				
<i>A. dielsii</i> E. Pritzel		G				
<i>A. divergens</i> Benth.		G				
<i>A. durinsecula</i> W. V. Fitz.		G				
<i>A. erinacea</i> Benth.	S.A.	G				
* <i>A. erioclada</i> Benth.		G				
* <i>A. extensa</i> Lindl.		G				
<i>A. fragilis</i> Maid. and Blakely		G				
* <i>A. glaucoptera</i> Benth.		No galls found by present author				
<i>A. gonophylla</i> Benth.		G				
<i>A. hastulata</i> Smith.		G				
<i>A. intricata</i> S. Moore		G				
<i>A. ixioophylla</i> Benth.	N.S.W., Qld.	E				
<i>A. gibberdingensis</i> Maid. and Blakely		G			G	
<i>A. kochii</i> W. V. Fitz. ex. Ewart and White		G				
<i>A. lasiocalyx</i> C. Andrews		G	G	G	G	
<i>A. leptoneura</i> Benth.		G				
<i>A. leptopetala</i> affin. Benth.	S.A., N.S.W., Qld.	G				
* <i>A. ligustrina</i> Meissn.		G				
<i>A. longiphyllodinea</i> Maid.		Not specified				
<i>A. merrallii</i> F. Muell.	S.A.	E				
* <i>A. merrallii</i> F. Muell. var. <i>tanminensis</i> E. Pritzel		G				
<i>A. multipicata</i> Benth.		G				
<i>A. myrtifolia</i> (Smith) Willd. var. <i>angustifolia</i> Benth.		G				
<i>A. neurophylla</i> W. V. Fitz.		G				
<i>A. nigricans</i> (Labill.) R. Br.		G				
<i>A. nigripilosa</i> Maid.		G				
<i>A. prainii</i> Maid.	S.A.	G				
<i>A. resinomarginea</i> W. V. Fitz.		G				
<i>A. restiacea</i> Benth.		G				
<i>A. rossei</i> F. Muell.		G				
<i>A. rostellifera</i> Benth.		E				
<i>A. scirpifolia</i> Meissn.		G				
<i>A. sclerosperma</i> F. Muell.		G				
<i>A. signata</i> F. Muell.	S.A., N.T.	G		G	G	
<i>A. spathulata</i> F. Muell. ex Benth.		G				
<i>A. sphacelata</i> Benth.		G				
<i>A. stereophylla</i> Meissn.		G				
* <i>A. "stowardii"</i> S. Moore		Not examined by present author				
<i>A. sulcata</i> R. Br. var. <i>platyphylla</i> Maid. and Blakely		G				
<i>A. tanumbirinense</i> Maid.	Qld., N.T.	G				
<i>A. teretifolia</i> Benth.		G				
<i>A. trachamiana</i> W. V. Fitz.		G				
<i>A. trigonophylla</i> Meissn.		G				
<i>A. triptycha</i> F. Muell. ex. Benth.		G				
<i>A. tysonii</i> Luehm.					G	
<i>A. ulicina</i> Meissn.		Not specified				
<i>A. urophylla</i> Benth. in Lindl.		G	G	G		
<i>A. xerophila</i> W. V. Fitz.		G				
<i>Albizzia distachya</i> (Vent.) MacBride.		G				

* recorded as hosts in W.A. before this study began (Carne 1925) (MacNish 1963).

G indicates globose and E elongated, galls



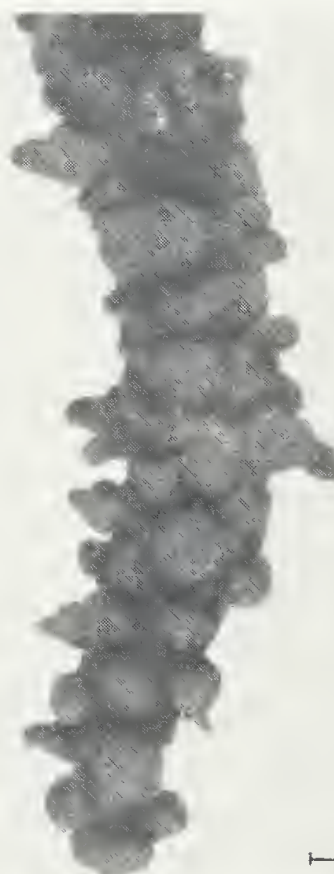
1

1 cm.



2

1 cm.



3

1 cm.

Figure 1.—Globose gall on the stem of an *A. cyanophylla*.

Figure 2.—Infected and uninfected inflorescences of *A. lasiocalyx*. The infected inflorescences are in the early stages of gall development. They are elongated and contorted, and flower opening is earlier than that occurring on a normal inflorescence.

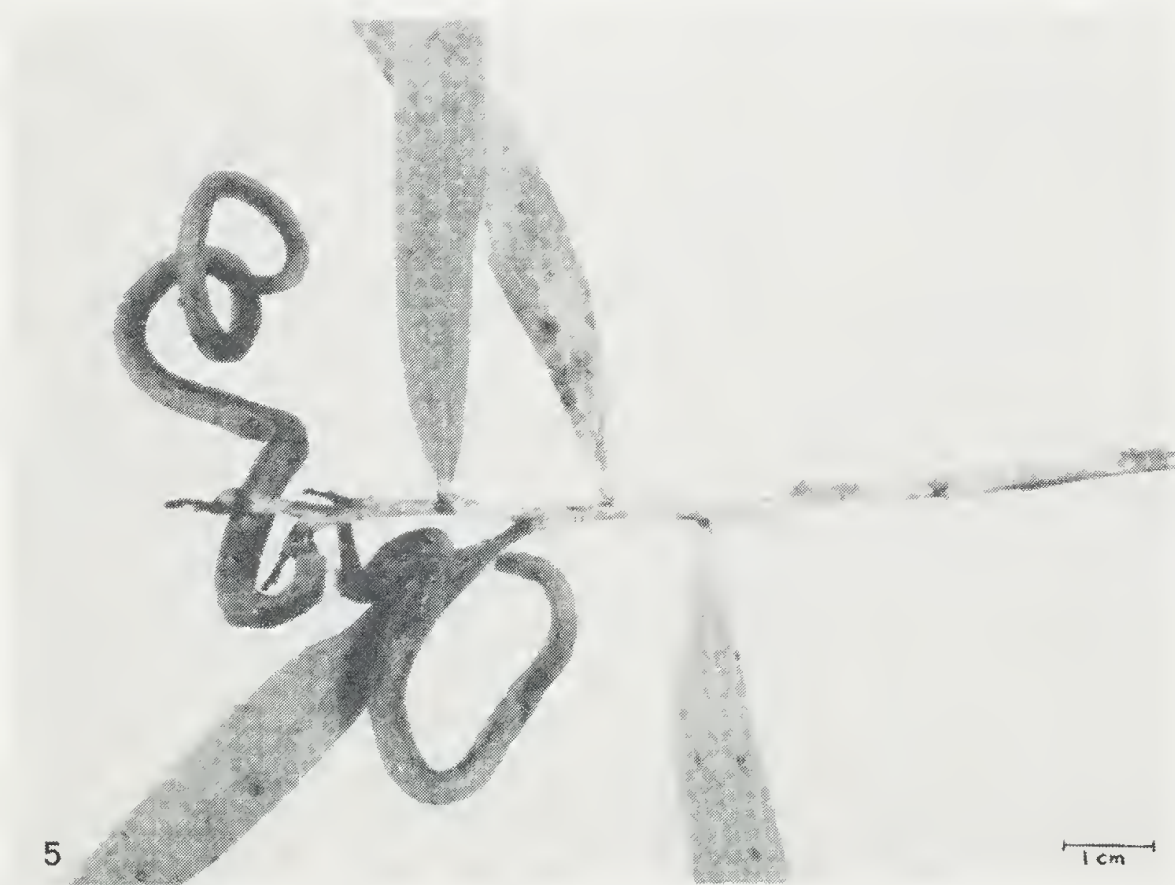


Figure 3.—A fully developed inflorescence gall of *A. lasiocalyx*. Abortive fruits are projecting from the main gall.

Figure 4.—An elongated stem gall on *A. rostelifera*. Galls develop at the point of branching of the stems. The old, larger galls occur towards the base of the plant.

Figure 5.—Long and twisted fruit galls of *A. bivenosa*.

lineolata Benth., *pilosa* Benth., *meissneri* Lehm. ex Meissn., *saligna* Wendl., *sowdenii* Maiden, *subcaerulea* Lindl.

Symptoms of the Disease

Conspicuous galls develop on the infected part of the host and in some instances witches' brooms and juvenile foliage may be produced. Severe infection by *U. tepperianum* ultimately results in the death of the host.

The types of galls which develop may be classified according to the shape of the gall and the organ which is affected. The galls may be globose or elongated, depending upon the extent to which the mycelium ramifies within the host tissue. In an elongated gall the fungus penetrates the host quite extensively, whereas in a globose gall the host reaction is more effective and restricts the parasite to a smaller area. The elongated and globose type of gall have not been found to occur on the one host species except for *A. bivenosa* (where different organs are involved) but appear to be mutually exclusive.

Stem, phyllode, peduncle and fruit galls have been observed on *A. cyanophylla*. Stem, phyllode, peduncle and inflorescence galls have been observed on *A. lasiocalyx*. Thus, in these two host species, *U. tepperianum* is capable of infecting and inducing gall formation in a number of organs. As all the galls are globose, the host reaction to parasitic invasion, in terms of localisation of mycelium, is apparently independent of the organ involved.

An examination of populations from widely separated areas at Geraldton, City Beach, Rockingham and Point Peron has revealed only stem galls in infected *A. rostellifera*. Similarly many fruit galls and one instance of a stem gall have been observed in populations of *A. bivenosa* plants investigated at Peppermint Grove, Reabold Hill and Fremantle. Thus the rust is consistent for the host part in which it induces gall formation, in any given species.

The reaction of *A. cyanophylla* does not vary with the part infected. Conspicuous perennial globose galls ranging in size from 0.5 cm. to 7.0 cm. in diameter develop.

Figure 1 shows a large stem gall on *A. cyanophylla*. Globose perennial galls develop on the stems and phyllodes of *A. lasiocalyx* in the same manner. When the young inflorescence of this

species is infected its normal development is disturbed. There is an elongation and increase in the diameter of the spike which results in a separation of the individual flowers (Figure 2). Fertilisation and initial fruit development may occur in a very few flowers but in the majority, development is arrested before the flowers open. No mature seeds are produced. A gall measuring up to 13.0 cm. in length and 3.5 cm. in diameter with protruding abortive fruit may result (Figure 3).

Infection of *A. rostellifera* results in a perennial type of gall which is very different from that produced on *A. cyanophylla* or *A. lasiocalyx*, although the period of gall growth is very similar. The galls develop mainly at the points of branching of the stems and may measure as much as 18.0 cm. in length and 6.0 cm. in diameter. Thus the gall is an elongated structure with the greatest diameter in the central portion (Figure 4).

Very conspicuous twisted annual fruit galls develop in *A. bivenosa* as the result of infection of the ovary after fertilisation has occurred (Figure 5). Ovule development is arrested and no mature seeds are produced. Mature normal fruits may measure up to 25.0 cm. in length and 1.5 cm. in diameter.

Acknowledgements

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15.—The common 'colonial' spider *Ixeuticus candidus* (Koch) and its synonyms (Dictynidae: Araneae)

by Barbara York Main *

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Abstract

The synonyms of the widespread Australian dictynid spider *Ixeuticus candidus* (Koch) are discussed. The nest and web are described and the species is distinguished from *Ixeuticus martius* (Simon).

Introduction

The small dictynid spider, *Ixeuticus candidus* (Koch) (fig. 1) is widespread throughout Australia and has aroused interest because of its alleged 'colonialism', a habit rare amongst spiders.

Taxonomy

Ixeuticus candidus (Koch 1872).

Amaurobius candidus Koch, 1872, pp. 333-334, pl. 26 fig. 6.

Ixeuticus candidus Roewer, 1954, p. 1368.

Phryganoporus candidus Lehtinen, 1967, p. 259.

Notes on synonyms

Simon (1908) erected the genus *Phryganoporus* to contain his earlier described species *Amaurobius gausapata* (Simon 1906) and the two new species *P. tubicola* and *nigrinus*. He recorded that the spiders were gregarious or social. I consider these three forms of Simon's are the one species, and synonymous with *Ixeuticus candidus* (Koch 1872). This species was described by Koch under the name *Amaurobius candidus* (Koch 1872). The type came from Bowen, Queensland. Roewer (1954) transferred the species to *Ixeuticus* to which genus it has since generally been referred.

Lehtinen (1967) sank the genus *Ixeuticus* in *Badumna* but transferred *candidus* to *Phryganoporus* and synonymised *P. gausapata* with it, thus erecting the new combination: *Phryganoporus candidus* (Koch 1872). However Leech (1971) retained *Ixeuticus* and discussed *I. candidus* but did not consider the status of *Phryganoporus*. One feature formerly regarded as distinguishing *Phryganoporus* from *Ixeuticus* was the undivided cribellum of *Phryganoporus* (Simon 1908 and Main 1964, 1967). Recent more detailed examination of specimens has subsequently shown the cribellum to have a faint dividing line (fig. 2) (specimens in author's collection). Thus this feature can no longer be considered a generic character.

The present author regards *Amaurobius candidus* Koch [= *Ixeuticus candidus* (Koch)] and *Phryganoporus gausapata* (Simon) as synonyms but retains the genus *Ixeuticus* into which

the species is placed. *Phryganoporus tubicola* Simon and *P. nigrinus* Simon are here also synonymised with *Ixeuticus candidus* (Koch).

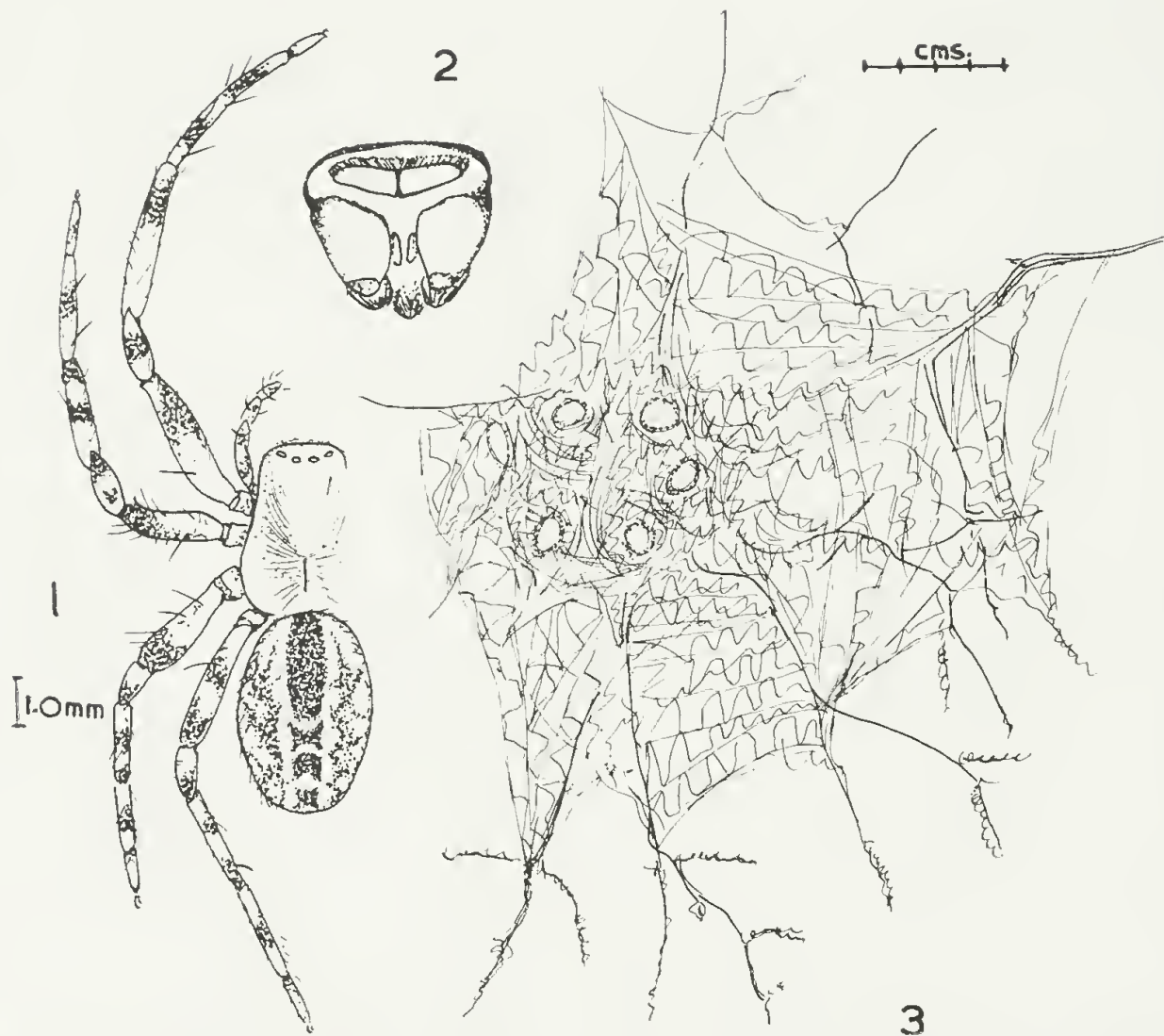
Natural History

Amongst the few records of 'socialism' or web colonies of spiders, the example of *Ixeuticus candidus* has been included, both under this name (McKeown, 1963) and that of *Phryganoporus gausapata* (Simon 1908, Dalmás 1917 and Main 1964, 1967). However from the author's observations it appears that the spiders are gregarious only during the juvenile stages. The nests are made in foliage. Typically, a solitary nest consists of a tough silk tube up to about two inches long, from the mouth of which extends a lacc-like snare web. The spider mates in the summer, and eggs are found in the retreat tube in early autumn. Through the winter and spring the young spiderlings construct their own individual snares and tiny retreats around the parent tube until the whole aggregate takes on the appearance of a 'colony' (fig. 3). Later, individual nests are made. However it is not known whether sibling matings take place in the brood colonies or whether mating occurs more randomly after the spiders have dispersed. In any case the gregariousness has not been observed amongst adults.

Discussion on the Distribution of *Ixeuticus candidus* and its Relationship to *Ixeuticus martius*

Dondale (1966) and Leech (1971) emphasise the similarity of *I. candidus* to *I. martius* (Simon) and the latter author even considered the possibility of synonymy. However there are marked differences between the two species. The abdominal pattern of an anterior dorsal median stripe followed by several distinct chevrons (sometimes reduced to a series of spots) and the distinct leg annulations (fig. 1) distinguish *I. candidus* from the less conspicuously marked and generally larger *I. martius*. *I. martius* builds a simple d'oyley-like lace web with short retreat funnel on vegetation, buildings, walls and fences, especially on timber structures (author's observations). *I. candidus* builds a silk tube from which a small silk snare radiates. Hickman (1967) notes these web differences and mentions the "cocoon" like nest of *I. candidus*. He also gives clear diagnostic photographs of spiders of the two species (1967). Main (1964, 1967) figured the spider and a solitary and 'colonial' nest under the name *Phryganoporus*.

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Figures 1-3.—*Ixauticus candidus* (Koch). 1, adult female spider. 2, spinnerets and cribellum. 3, 'colonial' web and retreat tubes of juvenile spiders.

I. martius occurs in New Zealand, eastern Australia and Tasmania. It has also been recorded as an introduction in California; first by Gertsch (1937) who described it under the name of *Hesperauximus sternitzkii*. Marples (1959) subsequently noted the synonymy. Leech (1971) again noted the Californian occurrence and listed localities where it occurs. *I. martius* has not been recorded from Western Australia.

I. candidus occurs in eastern Australia and Tasmania and is common in south-western Australia where it has formerly been identified as *Phryganoporus* (Simon 1908 and Main 1964, 1967).

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